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BrightLights: Gamifying Data Capture for Situational Visual Impairments

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ABSTRACT
Situational visual impairments (SVIs) create accessibility challenges, which is an increasing problem with the popularity of mobile devices. We introduce BrightLights, a game to model the way in which content design affects the onset of SVIs. By using a game as a research tool, we can encourage a much larger number of people to take part. The data we receive will inform new design guidelines to support designers of mobile content in reducing SVIs. An initial evaluation with 15 participants showed that participants performed significantly worse under 0% screen-brightness compared to 50% and 100% screen-brightness. We outline the next steps we must take before our planned large-scale study.

ACM Classification Keywords
H.5.m. Information Interfaces and Presentation (e.g. HCI): Miscellaneous.

Author Keywords
Situational impairment; accessibility; mobile devices; games.

INTRODUCTION AND BACKGROUND
Mobile devices conveniently let us complete many tasks and are ubiquitous beyond personal use, e.g., tablets are now used in schools [5], iPads are replacing pilot reference manuals [20], and neurologists can access information (e.g., patient records) more easily inside and outside the clinic [3]. These diverse use contexts increase potential situational impairments, a phenomenon recognised in HCI over many years [10, 16, 21].

In this study, we focus on mobile device Situational Visual Impairments (SVIs), e.g., the difficulty of using a smartphone on a sunny day. Mobile devices are susceptible to degraded image quality as ambient light increases [7] and exposure to glare can reduce the contrast sensitivity of the visual system [12]. This is even more pronounced if there is a existing disability. We still have a lot to understand regarding mobile device situational impairments [14], and in particular for severely constraining situations [15]. There are several contributing factors to SVIs, one of which is content design [18], yet, mobile designers are not well supported in dealing with SVIs and requested improved guidelines, education, and digital design tools [19]. Mobile designers are advised in popular mobile OS design guidelines [2, 1, 9] to use the Web Content Accessibility Guidelines (WCAG) 2.0 [4] for sufficient text and icon contrast, however, those guidelines were calculated on a large display desktop set up [11], which may be unsuitable for mobile. WCAG 2.1 did not update screen contrast criteria [8].

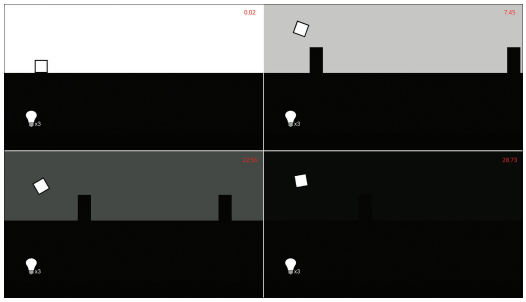

Figure 1. A demonstration of the BrightLights Gameplay.

Before we can introduce new design guidelines, we need to collect ecologically valid data on a large scale due to the complexity of mobile device SVIs. A previous large-scale online study found increasing ambient brightness and decreasing screen brightness can reduce people's colour differentiation abilities [13], however, the majority of participants did not use a mobile phone or tablet and the data suggested the participants took part under reasonable viewing conditions. While motivating people to engage with research is a challenge, user enjoyment can be increased by adding game elements to tasks [6].

We introduce BrightLights, an endless-runner game that challenges a player to overcome obstacles. As the player progresses, the background transitions from white to black reducing the contrast and increasing the game difficulty. During play-through, data about the user's performance is collected and stored. Initial findings demonstrate significantly worse performance under the 0% screen-brightness condition in comparison to 50% and 100% screen-brightness conditions.

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SYSTEM OVERVIEW

BrightLights was developed through a series of user-centered design iterations. The player is represented by the white block on the left side. Black blocks (obstacles) appear from the right, and the player taps on the screen to jump over those blocks. The background slowly changes from white to black (see Figure 1), reducing the contrast and increasing game-play difficulty. If the player collides with an obstacle, the square changes to the current background colour, making it more difficult for the player to see the square and adding elements of gamification. The background and the block is reset to white by pressing the light bulb. Players should press this when it is too difficult to distinguish the background and foreground. The game data is logged for future analysis.

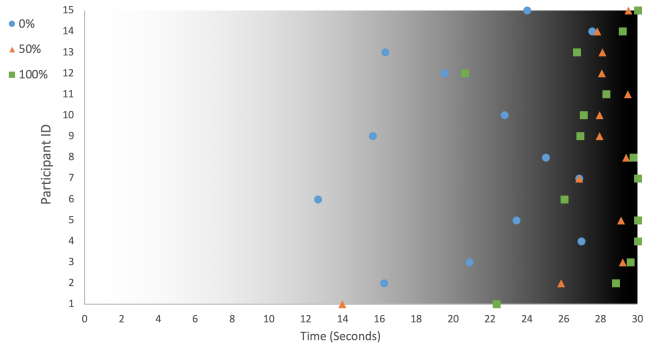

Figure 2. Average time (secs) and background colour when the bulb is pressed during the 0%, 50%, and 100% screen brightness trials.

EVALUATION

Participants and Procedure

Fifteen participants (9 male, 5 female, 1 preferred not to say) with a mean age of 21.5 years-old (21-25 years-old) took part.

Participants read an information sheet and completed a consent form as per our REB approval. No participant played endless runner games more than occasionally so were given a training session (max 5 minutes) with a popular endless runner [17].

We counterbalanced the three levels of the independent variable (***screen brightness***). These were determined by setting the brightness to 0% (3cd/m^2), 50% (202cd/m^2) and 100% (407cd/m^2) on a OnePlus 3T phone, with a 5.5" screen.

The primary dependent variable was the time at which the light bulb was pressed. Other dependent measures recorded include the background colour (which directly correlates with time), and the number of bulbs remaining. The ambient light level of the room was also measured and other independent measures were recorded via demographic questionnaires.

Results

The mean ambient lighting level of the room where the study took place was calculated at 26.73lx (range: 12-45lx).

A one-way repeated-measures ANOVA was conducted to identify how screen brightness affected performance when contrast diminished. The participants had three attempts at each level of brightness and an average time was used for analysis (Figure 2 shows an overview of participant performance). P1 and P6 had incomplete data due to ending their runs early by failing to reset the brightness in time and therefore could not be included in the analysis due to listwise deletion. Mauchly's test indicated that the assumption of sphericity was not violated (p = .24). The results show that task performance (i.e., trial time) was significantly reduced when screen brightness was lower, $F(2, 24) = 21.62$, $p < .001$. Bonferroni-corrected pairwise comparisons revealed a significant difference between the 0% and 50% and the 0% and 100% screen brightness conditions (p < .001), however, there was no significant difference between the 50% and 100% screen brightness conditions.

DISCUSSION AND FUTURE WORK

BrightLights is the first system being used to gamify the gathering of contrast ratio data. We demonstrate that the perception of low contrast objects becomes significantly more difficult to see when screen brightness is 0% compared to 50% and 100% brightness levels, which is consistent with previous research.

We can consider the main function of BrightLights a success: creating a game that would adjust the screen content over time to increase the difficulty of game play. However, BrightLights requires further refinement and a full evaluation before we can confidently use it in a large-scale study.

During the evaluation we manually measured the room and set the screen brightness. To forego the need for a researcher being present, we plan for BrightLights to utilise the mobile device's light sensor and identify the screen brightness level. In doing so, we will strengthen the independence of the game in successfully gathering data in-the-wild.

There are potential issues with building the data collection into a game because participants are likely to perform differently. We plan to run a thorough evaluation comparing the data from BrightLights used in-the-wild against data from a controlled lab study (e.g., using the DENOTE method [22]). We can conduct a rigorous analysis of the data to understand the interacting variables (i.e., ambient brightness, screen brightness, and content contrast) in a lab vs in-the-wild setting. When we are certain that the accuracy of BrightLights is equal to (or better than) a controlled study we will deploy the game for large-scale data collection.

CONCLUSION

Situational visual impairments (SVIs) become a greater concern with the increased use and reliance of mobile devices. It is necessary to understand SVIs so that effective support can be provided. We introduce an endless runner game called BrightLights, which decreases the background colour as the player progresses to increase the difficulty in avoiding obstacles. Data is recorded during the game play and can be used to model the way in which content design affects the onset of SVIs. Our initial evaluation showed participants performed significantly worse under 0% screen-brightness conditions compared to 50% and 100% screen-brightness conditions. However, before we can use BrightLights in a large-scale study, we need to further refine the game and run a more comprehensive evaluation in a controlled environment to determine if gamifying the collection of this data is reliable.

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